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### (54) Nonwoven fabric laminates

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## Description

This invention relates generally to a fabric laminate which has layers that are thermally bonded and are made from a low crystalline olefin copolymer, a low crystalline olefin terpolymer, or a low crystalline blend of olefin polymers. The fabric laminate of the present invention is softer, is stronger, is more abrasion resistant, and has reduced particle emission as compared to current SMS fabric laminates.

Nonwoven fabric laminates are useful for a wide variety of applications. Particularly, nonwoven fabric laminates are useful for wipers, towels, industrial garments, medical garments, medical drapes, sterile wrap, and the like. Fabric laminates, such as spun-bonded/melt-blown/spun-bonded (SMS) fabric laminates, made of isotactic polypropylene have achieved widespread use in operating rooms for drapes, gowns, towels, sterile wraps, footcovers, and the like. Such fabric laminates are well known as shown in US-A-4,041,203 assigned to Kimberly-Clark Corporation, the assignee of the present invention. For a number of years, Kimberly-Clark has manufactured and sold SMS medical fabric laminates under the marks Spunguard®, Evolution®, and Kimguard®. Such SMS fabric laminates have outside spun-bonded layers which are durable and an internal melt-blown barrier layer which is porous yet which inhibits the penetration of fluids and bacteria through the composite fabric laminate. The layers are thermally bonded together by spot bonding in discrete areas of the fabric.

Generally, such conventional SMS medical fabric laminates are made from layers of spun-bonded and melt-blown polypropylene. Commercially available isotactic polypropylene has a crystallinity of from 45-65% and a relatively narrow melt temperature range. While SMS fabric laminates made from commercial polypropylene exhibit satisfactory attributes in terms of tensile strength, resistance to fluid and bacteria penetration, breathability, and cost, there appears to be advantages to be gained from improving the drape, abrasion resistance, tear strength, and particle emission of the SMS fabric laminates made from polypropylene.

Conventional SMS fabric laminates made of isotactic polypropylene have not achieved widespread use as garments and protective coverings in more demanding clean rooms, particularly sterile clean rooms, and in paint rooms because of the higher requirements for such uses and such SMS fabric laminates tend to emit particles, either particles from the fabric itself or by passage of particles from the wearer to the atmosphere.

It is therefore an object of the present invention to provide a fabric laminate which is softer, is stronger, is more abrasion resistant, and has reduced particle emission as compared to current fabric laminates that are thermally spot bonded and are made of isotactic polypropylene.

It is particularly an object of the present invention to provide a fabric laminate which has equivalent tensile strength but higher tear strength than current fabric laminates made from polypropylene.

It is further an object of the present invention to provide a fabric laminate having greater extensibility and greater tensile energy than conventional fabric laminates made from polypropylene.

A further object of the present invention is to provide a fabric laminate which has greater abrasion resistance than existing fabric laminates made from polypropylene.

It is also an object of the present invention to provide a fabric laminate having improved fabric drape and softness as compared to fabric laminates made from polypropylene.

It is an object of the present invention to provide a sterile wrap that has enhanced attributes in terms of softness, strength, and abrasion resistance.

It is also an object of the present invention to provide a surgical gown that has enhanced attributes in terms of softness, strength, and abrasion resistance.

It is also an object of the present invention to provide a fabric laminate having reduced particle emission as compared to fabric laminates made from polypropylene.

It is additionally an object of the present invention to provide a protective garment having reduced particle emission for use in clean rooms, particularly sterile clean rooms, and paint rooms.

It is likewise an object of the present invention to provide a protective garment having reduced particle emission which can be sterilized without significant degradation of the low particle emission characteristics of the garment.

The foregoing objectives are accomplished by a fabric laminate according to claims 1 and 5 in which at least some of the layers are formed from an olefin copolymer, terpolymer, or blends of olefin polymers. The polymers are formulated to produce a polymer having a crystallinity of less than 45%, preferably between 31-35% and most preferably about 32%. The resulting polymer has a broadened melt temperature range which allows for heat bonding of the fibers and filaments at a lower temperature and over a wider range of processing temperatures.

In one embodiment of the present invention, at least one of the layers of the fabric laminate are formed from a random polypropylene copolymer that has been produced by copolymerizing 0.5-5.0% by weight of ethylene randomly in the backbone to yield a polymer that is less crystalline and with a broader melting range than polypropylene itself. A preferred polymer is produced when 3.0% by weight of ethylene is copolymerized with the polypropylene. The resulting copolymer has a crystallinity of 32% and when spun into fibers or filaments and formed into webs produces the advantages recited in the foregoing objectives.

The fabric laminate of the present invention may preferably have all of the layers formed from a polymer having

5 reduced crystallinity although some advantages of the present invention may be realized where less than all of the layers of the fabric laminate are formed of the polymer of reduced crystallinity. Particularly, forming the outside layers of an SMS fabric laminate with a polymer of reduced crystallinity may be advantageous in terms of softness and abrasion resistance, but strength may be reduced because the melting range of the spun-bonded layers may be essentially the same as the melting range of the interior melt-blown layer formed of a polymer having a higher degree of crystallinity. Unless a melt temperature differential of about 10°-40°C exists between the spun-bonded and melt-blown layers, bonding will not be optimum and strength will be reduced.

10 The SMS fabric laminate of the present invention is particularly suited for the fabrication of protective garments for use in clean rooms, particularly sterile clean rooms, and paint rooms. Not only does the SMS fabric laminate have superior drape and abrasive qualities, the SMS fabric laminate has superior particle emission characteristics when compared to conventional SMS fabric laminates. As a result, garments fabricated from the SMS fabric laminate of the present invention are particularly suited for clean room environments where air born particles must be minimized.

15 Preferably low particle emission garments are constructed from an SMS fabric laminate in which the melt-blown layer is formed from high crystalline polypropylene and the spun-bonded layers are formed from a low crystalline copolymer (a C/P/C laminate). The copolymer is formed by copolymerizing 3.2% by weight of ethylene randomly in the backbone of the polypropylene. The resulting copolymer has a crystallinity of less than 32%.

20 Where garments fabricated with the SMS fabric laminate of the present invention are used in a sterile environment, such as a pharmaceutical manufacturing facility, the SMS fabric laminate is treated with a hindered amine light stabilizer.

25 Other objects and advantages of the invention will become apparent upon reading the following detailed description of preferred embodiments of the present invention and upon reference to the drawings.

Figure 1 is a schematic diagram of a forming machine which is used in making the nonwoven fabric laminate of the present invention;

30 Fig. 2 is a cross section view of the nonwoven fabric laminate of the present invention showing the layer configuration;

Fig. 3 is a graph showing the melt temperature range of a polymer (polypropylene) used in making fabric laminates in accordance with the prior art;

35 Fig. 4 is a graph showing the melt temperature range of a copolymer used in making fabric laminates in accordance with the present invention;

Fig. 5 is a graph showing the particle emission results of a Helmke Drum Test for various fabrics;

Fig. 6 is a graph showing the particle emission results of clean room laundering test of garments made in accordance with the present invention; and

Fig. 7 is a perspective drawing of a clean room garment embodying the present invention.

40 While the invention will be described in connection with a preferred embodiment it will be understood that we do not intend to limit the invention to that embodiment. On the contrary, we intend to cover all alternatives, modifications, and equivalents as may be included within the scope of the invention as defined by the appended claims.

45 Turning to Figure 1, there is shown a schematic of a forming machine 10 which is used to produce an SMS fabric laminate 12 in accordance with the present invention. Particularly, the forming machine 10 consists of an endless foraminous forming belt 14 wrapped around rollers 16 and 18 so that the belt 14 is driven in the direction shown by the arrows. The forming machine 10 has three stations, spun-bond station 20, melt-blown station 22, and spun-bond station 24.

50 The spun-bond stations 20 and 24 are conventional extruders with spinnerettes which form continuous filaments of a polymer and deposit those filaments onto the forming belt 14 in a random interlaced fashion. The spun-bond stations 20 and 24 may include one or more spinnerette heads depending on the speed of the process and the particular polymer being used. Forming spun-bonded material is conventional in the art, and the design of such a spun-bonded forming station is thought to be well within the ability of those of ordinary skill in the art. The nonwoven spun-bonded web 32 is prepared in conventional fashion such as illustrated by the following patents: Dorschner *et al.* US-A-3,692,618; Kinney US-A-3,338,992 and US-A-3,341,394; Levy US-A-3,502,538; Hartmann US-A-3,502,763 and US-A-3,909,009; Dobo *et al.* US-A-3,542,615; Harmon CA-B-803,714; and Appel *et al.* US-A-4,340,563. Other methods for forming a nonwoven web having continuous filaments of a polymer are contemplated for use with the present invention.

55 Spun-bonded materials prepared with continuous filaments generally have at least three common features. First, the polymer is continuously extruded through a spinnerette to form discrete filaments. Thereafter, the filaments are drawn either mechanically or pneumatically without breaking in order to molecularly orient the polymer filaments and achieve tenacity. Lastly, the continuous filaments are deposited in a substantially random manner onto a carrier belt to form a web. Particularly, the spun-bond station 20 produces spun-bond filaments 26 from a fiber forming polymer. The filaments are randomly laid on the belt 14 to form a spun-bonded external layer 28. The fiber forming polymer is described in greater detail below.

The melt-blown station 22 consists of a die which is used to form microfibers 30. The microfibers 30 are randomly deposited on top of the spun-bond layer 28 and form a melt-blown layer 32. The construction and operation of the melt-blown station 22 for forming microfibers 30 and melt-blown layer 32 is considered conventional, and the design and operation are well within the ability of those of ordinary skill in the art. Such skill is demonstrated by NRL Report 4364, "Manufacture of Super-Fine Organic Fibers", by V.A. Wendt, E.L. Boon, and C.D. Fluharty; NRL Report 5265, "An Improved Device for the Formation of Super-Fine Thermoplastic Fibers", by K.D. Lawrence, R.T. Lukas, and J.A. Young; and US-A-3,849,241, issued November 19, 1974, to Buntin *et al.* Other methods for forming a nonwoven web of microfibers are contemplated for use with the present invention.

The melt-blown station 22 produces microfine fibers 30 from a fiber forming polymer which will be described in greater detail below. The fibers 30 are randomly deposited on top of spun-bond layer 28 to form a melt-blown internal layer 32. For an SMS medical fabric laminate, for example, the melt-blown barrier layer 32 has a basis weight of preferably about 11.87 to 16.96 g/m<sup>2</sup> (0.35-0.50 oz./yd.<sup>2</sup>). For a clean room garment, for example, the melt-blown barrier layer 32 of the SMS fabric laminate has a basis weight of preferably about 13.56 g/m<sup>2</sup> (0.4 oz./yd.<sup>2</sup>) to about 27.13 g/m<sup>2</sup> (0.8 oz./yd.<sup>2</sup>).

After the internal layer 32 has been deposited by the melt-blown station 22 onto layer 28, spun-bond station 24 produces spun-bond filaments 34 of polymer which are deposited in random orientation on top of the melt-blown layer 32 to produce external spun-bond layer 36. For an SMS medical fabric laminate, for example, the layers 36 and 28 each have a basis weight of preferably from about 11.87 g/m<sup>2</sup> (0.30 oz./yd.<sup>2</sup>) to about 40.7 g/m<sup>2</sup> (1.2 oz./yd.<sup>2</sup>). For a clean room garment, for example, the layers 36 and 28 of the SMS fabric laminate each have a basis weight of preferably from about 11.87 g/m<sup>2</sup> (0.3 oz./yd.<sup>2</sup>) to about 33.9 g/m<sup>2</sup> (1.0 oz./yd.<sup>2</sup>).

The resulting SMS fabric laminate web 12 (Fig. 2) is then fed through bonding rolls 38 and 40. The surface of the bonding rolls 38 and 40 are provided with a raised pattern such as spots or grids. The bonding rolls are heated to the softening temperature of the polymer used to form the layers of the web 12. As the web 12 passes between the heated bonding rolls 38 and 40, the material is compressed and heated by the bonding rolls in accordance with the pattern on the rolls to create a pattern of discrete areas, such as 41 shown in Fig. 2, which areas are bonded from layer to layer and are bonded with respect to the particular filaments and/or fibers within each layer. Such discrete area or spot bonding is well known in the art and can be carried out as described by means of heated rolls or by means of ultrasonic heating of the web 12 to produce discrete area thermally bonded filaments, fibers, and layers. In accordance with conventional practice described in Brock *et al.*, US-A-4,041,203, it is preferable for the fibers of the melt-blown layer in the fabric laminate to fuse within the bond areas while the filaments of the spun-bonded layers retain their integrity in order to achieve good strength characteristics.

A typical bonding pattern designated "H&P" has square pin bonding areas wherein each pin has a side dimension of 0.97 mm (.038 in.), a spacing of 1.78 mm (.070 in.) between pins, and a depth of bonding of 0.58 mm (.023 in.). The resulting pattern has a bonded area of about 29.5%. Another typical bonding pattern designated "714" has square pin bonding areas wherein each pin has a side dimension of 0.58 mm (.023 in.), a spacing of 1.57 mm (.062 in.) between pins, and a depth of bonding of 0.84 mm (.033 in.). The resulting pattern has a bonded area of about 15%. Another typical bonding pattern is the "EHP" bond pattern which produces a 15% bond area with a square pin having a side dimension of 0.94 mm (.037 in.), a pin spacing of 2.46 mm (.097 in.), and a depth of 0.99 mm (.039 in.). Typically, the percent bonding area varies from around 10% to 30% of the area of the fabric laminate web 12. As is well known in the art, the spot bonding holds the laminate layers together as well as imparts integrity to each individual layer by bonding filaments and/or fibers within each layer.

While the particular bonding pattern does not form any part of the present invention, the ability of the polymer filaments and fibers to bond within the discrete bond areas is important to providing a fabric laminate web 12 which has a high tear strength, high tensile energy, is abrasion resistant, has reduced particle emissions, and still has increased fabric drape and softness. In that regard, we have found that fabric laminates having layers formed from olefin copolymers, terpolymers, and blends of polymers having a crystallinity less than 45% provide improved thermal bonding and therefore improved fabric characteristics even though such polymers produce fibers with lower tenacity and lower modulus than those fibers formed from polypropylene. More preferably, at least some of the layers of the fabric laminate are formed from an olefin copolymer, an olefin terpolymer, or blend of olefin polymers having a crystallinity between 31-50%. Even more preferably, at least some of the layers of the fabric laminate are formed from an olefin copolymer, olefin terpolymer or blend of olefin polymers having a crystallinity of about 32%.

In order to achieve such a reduced crystallinity polymer for forming a layer for a fabric laminate, we have found that copolymerizing 0.5 to 5.0% by weight of ethylene randomly in the backbone of polypropylene produces a copolymer which is especially useful for spun-bonded webs and combinations of spun-bonded and melt-blown webs for use in producing a fabric laminate. Particularly, such a copolymer finds usefulness in producing SMS fabric laminates.

By using an olefin copolymer, olefin terpolymer, or blend of olefin polymers having a reduced crystallinity for producing laminate layers, the resulting modified thermoplastic polymer has a broadened melting range which achieves bonding at a lower spot bonding temperature and provides bonding over a broader range of temperatures encountered during the spot bonding process. With reference to Figs. 3 and 4, one can see graphically the broadened melt temper-

ature range that the propylene copolymer (3% ethylene) has (Fig. 4) as compared to higher crystallinity polypropylene (Fig. 3). For example, the polypropylene melts over a very narrow range of about 150-170°C. while the propylene copolymer (3% ethylene) melts over a broader and lower temperature range of about 125-160°C. It is believed that the reduced crystallinity of the copolymer, terpolymer, or polymer blend results not only in a fabric that is easier to process because of the broadened melt temperature range but also a polymer which bonds more securely without damage to the fibers than the higher crystallinity polymers, such as polypropylene, which are customarily used in manufacturing spun-bonded and melt-blown webs which are used to make SMS fabric laminates. Moreover, the copolymer in the spun-bonded layer makes the spun-bonded layer more compatible in bonding temperature to the interior melt-blown layer, even where the melt-blown layer is formed from a polymer of high crystallinity such as polypropylene. Consequently, the resulting bonding is more secure and the likelihood of pinholes occurring is reduced.

The fabric laminates of the present invention with improved strength, softness and drape, abrasion resistance, and particle emission are useful in a number of applications. For example, SMS fabric laminates embodying the present invention can be converted into surgical gowns, surgical drapes, sterile wrap, and clean room garments including sterilizable clean room garments.

The present invention is illustrated by comparison of SMS fabric laminates formed of unmodified high crystallinity polypropylene to SMS fabric laminates having at least some layers formed from a copolymer of 3% by weight of ethylene copolymerized randomly in the backbone of the polypropylene.

#### Example 1

In order to evaluate the effect of forming the layers of an SMS fabric laminate using a copolymer with reduced crystallinity, such as a propylene copolymer (3% ethylene), six samples of SMS fabric laminates were prepared and tested. The six samples are shown in Table 1 below which records their layer composition and the various tests that demonstrate the superiority of the fabric laminates formed from the copolymer in terms of higher tear strength, higher tensile energy, greater abrasion resistance, and increased fabric drape and softness.

Fabric laminate Samples 2, 4, and 6 are SMS fabric laminates which were prepared using an unmodified polypropylene polymer, particularly Exxon® PD3125 for the spun-bonded layers and Exxon® 3214 plus peroxide for the melt-blown layer. Such polypropylene polymers are manufactured and sold by Exxon Chemical Company of Baytown, Texas. The layers were bonded at a temperature of 143°C (290°F).

Fabric laminate Samples 1, 3, and 5 were prepared using the same process parameters as Samples 2, 4, and 6 respectively except that propylene copolymer (3% ethylene) was used for forming the layers instead of polypropylene and the bonding temperature was reduced. The copolymer is manufactured by Shell Oil Company and designated Shell® WRS 6-144 3% ethylene. The copolymer is produced by copolymerizing propylene with 3% by weight of ethylene.

As a result of the broadened melt temperature range of the copolymer, a lower bonding temperature, between 135-138°C (275°-280°F), was used to bond the layers of the SMS fabric laminate made from the copolymer. Consequently, the only difference between the preparation of Sample 1 and Sample 2 was the use of the 3% copolymer instead of unmodified polypropylene and a lower bonding temperature. Likewise the preparation of Sample 3 and Sample 4 and the preparation of corresponding Sample 5 and Sample 6 varied only in terms of the polymer used and the bonding temperature.

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TABLE 1

Sample	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6
Polymer	C/C/C	P/P/P	C/C/C	P/P/P	C/C/C	P/P/P
Pattern/fiber shape	EHP/ROUND	EHP/ROUND	EHP/ROUND	EHP/ROUND	714 ROUND	714 ROUND
Calender Temp (°F) °C	(280) 138	(292) 144	(278) 137	(292) 144	(275) 135	(290) 143
Basis Weight (osy) x 33.9 g/m <sup>2</sup>	1.58	1.59	1.42	1.40	1.49	1.42
Grab Tensile MD/CD (lbs) x 0.45 kg	22.9/20.9	21.3/20.9	19.8/19.2	21.7/20.2	23.1/19.2	19.5/16.1
Elongation MD/CD (%)	68.6/80.8	48.6/57.9	--	--	73/87	76/75
Peak Energy MD/CD (lbs) x 0.45 kg	29.1/28.7	19.3/20.4	23.0/27.1	--	40.5/39.2	39.1/29.8
Trap Tear MD/CD (lbs) x 0.45 kg	10.9/9.4	8.8/8.7	9.1/8.1	8.8/7.7	10.5/9.6	9.9/7.5
Taber Abrasion *Pin/Anvil (cycles)	89/60	53/39	87/22	51/24	52/29	11/8
Coefficient of Friction (fabric to fabric)	0.485	0.395	0.543	--	0.53	0.45
SST Softness (higher is softer)	67	29	87	33	96	86
Drape Stiffness MD/CD	3.3/2.5	3.3/2.7	3.1/2.4	--	3.4/2.1	3.7/2.3

\*Taber abrasion of 50 replicates/sample

With respect to Table 1 above, the "Polymer" line of Table 1 shows that Sample 1 is a three layer SMS fabric laminate using the propylene copolymer (3% ethylene) ("C/C/C") for each of the layers in the fabric laminate. By the same token, the Table shows that Sample 2 is a three layer SMS fabric laminate made with unmodified polypropylene ("P\|P"). Sample 2 was formed by the same process as Sample 1 except that a higher bonding temperature was used to bond the polypropylene layers of the fabric laminate.

The "pattern/fiber shape" line of Table 1 indicates that the standard spot bonding pattern "EHP" was used for Samples 1-4. For Samples 5 and 6, the "714" bonding pattern was used. The term "round" for each of the samples indicates the cross-sectional shape of the fiber which results from using a spinning orifice that is round. The basis weight of each sample was measured in g/m<sup>2</sup> (ounces per square yard) and is shown in the "Basis Weight" line of Table 1. Basis weight was measured in accordance with Federal Test Method (FTM) 191A-5.

The grab tensile strength in pounds was measured in both the machine direction and cross direction ("MD/CD"). The grab tensile strength was measured in accordance with FTM 191A, Method 5100. It can be seen from Table 1 that the grab tensile strength for the corresponding copolymer and polypropylene samples is essentially the same thereby indicating that the copolymer fiber and filaments with their lower tenacity and lower modulus do not, as expected,

reduce the grab tensile strength of the fabric laminate.

Elongation as a percentage was measured in both the machine and the cross-direction. As can be seen by comparing Samples 1 and 2, Sample 1, the copolymer fabric laminate sample, has substantially better elongation properties than that of the polypropylene fabric laminate sample, Sample 2. With respect to Samples 5 and 6, the elongation is essentially the same. The elongation was measured in accordance with FTM 191A, Method 5100.

With respect to peak energy, it can be seen that the copolymer fabric laminate Samples 1 and 5, have a substantial advantage over the polypropylene fabric laminate Samples 2 and 6 in terms of the peak energy characteristics. The peak energy was measured in accordance with FTM 191A, Method 5100.

With regard to trapezoidal tear strength, measured in pounds in both the machine and cross-direction, it can be seen that the copolymer fabric laminate Samples 1, 3, and 5 enjoy a substantial advantage over the respective polypropylene fabric laminate Samples 2, 4, and 6. Trapezoidal tear was measured in accordance with FTM 191A, Method 5450.

The abrasion of the fabric laminate was measured in accordance with the Taber Abrasion Test and shows that for respective samples the copolymer fabric laminates are more abrasion resistant than the polypropylene fabric laminates.

The abrasion resistance was measured in accordance with FTM 191A, Method 5306 at 50 replications per sample.

The softness of the respective copolymer fabric laminate samples as compared to the polypropylene fabric laminate samples is remarkably improved as indicated by the higher index number. The softness was measured by an in-house procedure similar to INDA Std. Test IST 90.0-75 (R-82).

The drape stiffness measured in centimeters in both the machine and cross-direction is less for the copolymer fabric laminate samples as compared to the respective polypropylene fabric laminate samples thereby indicating that the copolymer fabric laminates are more drapeable. Drape stiffness was measured in accordance with FTM 191A, Method 5206.

In summary with respect to strength and elongation, the copolymer fabric laminates consistently are 10-30% higher in elongation and peak energy than the polypropylene fabric laminates due to the lower crystallinity and better bonding of the fibers and filaments. The increased toughness is also reflected in the higher trapezoidal tear values.

There is no significant difference in grab tensile strength. The lower tensile strength which was expected for the less crystalline copolymer was likely overshadowed by the better bonding of the copolymer during the spot bonding process. Abrasion resistance, according to the Taber results, is consistently 40% greater for the copolymer fabric laminates as compared to the polypropylene fabric. The failure mechanism is the same for the copolymer fabric laminates as well as for the polypropylene fabric laminates with the EHP pattern. Both fabric laminates show equal amounts of fiber breakage and fibers pulled from the bond points. With the 714 pattern, the failure mechanism is predominantly fiber pulled from bonding points rather than the fiber breakage. The better abrasion resistance for the copolymer is attributed to better bonding and more flexible spun-bonded fibers.

With regard to the tactile properties for the fabric laminates, the copolymer fabric laminates appear better than the polypropylene fabric laminates. Physical and sensory panel evaluation reveals that the copolymer fabric laminates have slightly better drape, higher fabric to fabric friction, and higher drag against the skin than polypropylene fabric laminates. The copolymer fabric laminates produce a slight increase in fabric softness, and the sensory panel consistently judged the copolymer fabric laminates softer and less abrasive than polypropylene fabric laminates.

While work was done using the propylene copolymer (3% ethylene) described above, it is believed that the useful range for the ethylene is as stated between 0.5-5.0% by weight of ethylene. We have found, however, that as the ethylene content approaches 5.0% the fabric laminates begin to lose tensile strength although the fabric laminates seem to retain their other desirable attributes. Also at 5.0% ethylene the copolymer becomes difficult to process because of its adhesive characteristics.

#### 45 Example 2

In another set of tests, two conventional fabric laminates and two fabric laminates in accordance with the present invention were made and tested. The four samples are shown in Table 2 below which records their composition and the various tests that demonstrate the superiority of the fabric laminate formed from layers of copolymer in terms of higher tear strength, higher tensile energy, greater abrasion resistance, and increased fabric drape and softness.

Fabric laminates Samples 7 and 8 are SMS fabric laminates which were prepared using an unmodified polypropylene polymer, particularly Exxon PD3125 for the spun-bonded layers and Exxon 3214 plus peroxide for the melt-blown layer.

Samples 9 and 10 are fabric laminates which were prepared using essential the same process parameters as Samples 7 and 8 except that propylene copolymer (3% ethylene) was used for forming all of the layers instead of polypropylene and the bonding temperature was reduced. The copolymer was Shell WRS 6-144 3% ethylene. Samples 7 and 8 also differ from Samples 9 and 10 as a result of the use of a different spot bonding pattern and small variations in basis weight. A lower bonding temperature was used for the copolymer fabric laminates, Samples 9 and 10, because of the broader softening temperature range exhibited by the copolymer. The results are reported in Table 2:

TABLE 2

	Sample 7	Sample 8	Sample 9	Sample 10
Pattern-Material	EHP-P/P/P	EHP-P/P/P	714-C/C/C	714-C/C/C
Fiber Shape	round	round	round	round
Basis Wt. Total (MB)	1.4 (.35)	1.59 (.55)	1.55 (.43)	1.7 (.48)
Grab Tensile Strength (lbs) MD/CD x 0.45 kg	19.54/16.55	22.25/18.35	22.48/19.70	24.91/21.11
Grab Peak Energy (in-lbs) MD/CD x 11,43 mm·kg	14.89/14.59	20.49/16.26	24.02/22.48	24.67/24.52
Elongation (%) MD/CD	40.41/53.76	43.03/50.82	59.88/69.35	55.59/69.26
Trapezoidal Tear Strength (lbs) MD/CD x 0.45 kg	6.68/5.74	7.37/8.11	9.15/7.67	8.78/7.80
Trapezoidal Tear Strength Post Irradiation (lbs) x 0.45 kg MD/CD	6.68/5.74	7.37/8.11	7.32/6.14	7.22/6.40
Taber Abrasion (cycles) Face/Anvil	20/12	15/11	14/8	14/6
SST Softness (mm)	67.5	51.6	61.5	53.6
Drape Stiffness (cm) MD/CD	3.8/2.1	3.5/2.1	3.6/2.4	3.6/2.4

With reference to Table 2, the first line entitled "Pattern-Material" indicates the bonding pattern, either "EHP" or "714", and the material, polypropylene or the copolymer, used in each of the layers. For example, Sample 7 is a three layer SMS fabric laminate having all three layers made of a high crystalline polypropylene whereas Sample 9 is a three layer SMS fabric laminate with all three layers made from a propylene copolymer (3% ethylene). The next line of Table 2 describes the shape of the fiber or filament. The line entitled "Basis Weight Total (MB)" shows the total basis weight of the three layer laminate and the basis weight of the internal melt-blown layer in parenthesis. For example, in Sample 7 the total fabric laminate has a basis weight of 47.47 g/m<sup>2</sup> (1.4 oz/yd<sup>2</sup>) with the internal melt-blown layer having a basis weight of 11.87 g/m<sup>2</sup> (.35 oz/yd<sup>2</sup>). Consequently, each spun-bonded exterior layer is just slightly greater than 16.96 g/m<sup>2</sup> (.50 oz/yd<sup>2</sup>).

With regard to the grab tensile strength, it can be seen from Table 2 that the grab tensile strength for the copolymer and polypropylene fabric laminate samples is essentially the same thereby indicating that using the copolymer does not, as expected, reduce the grab tensile strength of the fabric laminate. It should be appreciated, however, that direct comparisons between the polypropylene fabric laminates and the copolymer fabric laminates listed in Table 2 may be overshadowed by the use of the different bonding patterns for the polypropylene fabric laminates and the copolymer fabric laminates. In Table 2 it also appears that the basis weight might also effect strength.

With respect to peak energy, it can be seen that the copolymer fabric laminates, Samples 9 and 10, possess higher peak energy than the polypropylene fabric laminates, Samples 7 and 8. Again, those differences may in part be masked by the use of the different bonding patterns.

With respect to elongation, it can be seen that the copolymer fabric laminates, Samples 9 and 10, have a greater percentage elongation than the polypropylene fabric laminates, Samples 7 and 8. Again, the true value of the difference may be masked by the different bonding patterns used.

With respect to trapezoidal tear strength, it can be seen that the copolymer fabric laminates are stronger or at the very least comparable to the polypropylene fabric laminates.

With respect to abrasion, the copolymer fabric laminates, Samples 9 and 10, do not perform as well as the polypropylene fabric laminates either with respect to the Taber Abrasion Test. It is believed that the poor abrasion performance is due to the difference in bonding pattern used for the copolymer fabric laminates and for the polypropylene fabric laminates. In any event, the loss of abrasion resistance is not so great as to make a substantial difference in performance for the copolymer fabric laminates.

With regard to softness and drape, it can be seen that the copolymer fabric laminates, Samples 9 and 10, are of equal softness to the polypropylene fabric laminates with respect to the SST softness test and the drape stiffness test.

In summary, the fabric laminates, Samples 9 and 10, consisting of layers formed from the copolymer have improved peak energy, improved tear strength, and comparable abrasion resistance to the conventional polypropylene fabric laminates, Samples 7 and 8.

Example 3

5 While the fabric laminate samples made in accordance with the present invention and described above used the copolymer for all of the layers of the fabric laminate, some of the advantages of the present invention can be achieved by using the copolymer, terpolymer, or blend in less than all of the layers of the fabric laminate.

10 Two additional fabric laminate Samples 11 and 12 were prepared and tested. The two samples, Samples 11 and 12, are shown in Table 3 below.

15 Sample 11 is an SMS fabric laminate having the spun-bond layers formed from the propylene copolymer (3% ethylene) and the interior melt-blown layer formed from high crystalline polypropylene. Sample 12 is an SMS fabric laminate with all three layers formed from high crystalline polypropylene as previously described in connection with Example 1. The polypropylene used in the melt-blown layers of both samples was Himont PF-015 manufactured by Himont USA, Inc., Wilmington, Delaware. The spun-bonded layers in Sample 12 are formed from Himont PC 973. The composition of the two samples and test results are reported in Table 3:

TABLE 3

		Sample 11	Sample 12
20	Pattern-Material	714-C/P/C	714-P/P/P
25	Fiber Shape	round	round
30	Basis Wt.Total (MB)	Test History 1.7(0.40)	1.7(0.40)
35	Grab Tensile Strength (lbs) MD/CD x 0.45 kg	At time of mfg. 3 wks after mfg.	19.2/20.0 20.6/19.2
	Grab Peak Energy (in-lbs) MD/CD x 11.43 mm · kg	3 wks after mfg.	23.0/21.8 23.8/21.6
	Trap Tear (lbs) MD/CD x 0.45 kg	At time of mfg. 2 wks after mfg.	17.9/18.7 8.7/7.8
	Taber (cycles to endpt.)	3 wks after mfg.	10.3/7.3 8.0/8.0
	Crush Energy (g · mm)	At time of mfg. 2 wks after mfg.	26/9 4240 4200
	SST Softness (mm)	2 wks after mfg.	4860 53 45

40 It was observed that the grab tensile strength of the SMS fabric of Sample 11 was lower than that of SMS fabric having all three layers formed of the propylene copolymer (3% ethylene) and lower than that of conventional SMS fabric having all three layers formed of propylene polymer. It is believed that this reduction in the grab tensile strength may be due to the fact that the softening temperature of the propylene copolymer (3% ethylene) used in the spun-bonded layers is lower than that of the propylene polymer. Consequently, the filaments in the spun-bonded layers may have fused excessively in the bond areas thus leading to the reduced strength of the fabric laminate.

45 With reference to Table 3, Sample 11, as predicted because of the reduced softening temperature differential, has reduced grab tensile strength as compared to the conventional polypropylene fabric laminate, Sample 12. The grab peak energy of Sample 11, however, is essentially the same as the grab peak energy for the conventional fabric laminate, Sample 12, because the higher elongation offsets the reduced tensile strength. The trapezoidal tear strength of Sample 11 made in accordance with the present invention is greater than the trapezoidal tear strength for conventional Sample 12.

50 Sample 11, also, outperforms the conventional Sample 12 in terms of abrasive resistance as shown by the Taber Abrasion Test.

With regard to softness, Sample 11, also outperformed the conventional Sample 12 in terms of the SST Softness Test.

55 As previously indicated, the fabric laminates of the present invention have reduced particle emissions when strained or flexed when compared to the particle emissions from conventional fabric laminates formed from isotactic polypropylene fibers and filaments. SMS fabric laminates made in accordance with the present invention emit up to fifty times fewer particles greater than 0.3 microns in diameter when compared to a conventional SMS fabric laminate formed of isotactic polypropylene. Consequently the fabric laminates of the present invention are particularly useful for making clean room garments.

Clean rooms are classified according to the number of particles of a particular size per cubic foot of air. Federal Standard 209D (FED-STD-209D) provides a particle distribution in accordance with the following Table 4 for the classification of clean rooms:

5

TABLE 4

10	15	20	Class	Measured Particle Size (Micrometers)				
				0.1	0.2	0.3	0.5	5.0
1	35	7.5	3	1	NA			
10	350	75	30	10	NA			
100	NA	750	300	100	NA			
1,000	NA	NA	NA	1,000	7			
10,000	NA	NA	NA	10,000	70			
100,000	NA	NA	NA	100,000	700			
(NA. - not applicable)								

#### Example 4

25 In order to demonstrate the improved particle emissions characteristics of fabric laminates made in accordance with the present invention, four SMS fabric laminate samples were prepared and tested. The results are recorded in Table 5. Two samples, Samples 13 and 14, are conventional SMS fabric laminates prepared from isotactic polypropylene. Particularly, Sample 13 is a 6.1 g/m<sup>2</sup> (1.8 oz/yd<sup>2</sup>) SMS fabric laminate having its layers bonded with an EHP bond pattern. Sample 14 is a 50.1 g/m<sup>2</sup> (1.5 oz/yd<sup>2</sup>) SMS fabric laminate which likewise has been bonded with an HP bond pattern.

30 Two samples made in accordance with the present invention, Samples 15 and Samples 16, were made using a propylene copolymer (3.2% ethylene) for the external spun-bonded layers. The internal melt-blown layer was formed from isotactic polypropylene. Particularly, Sample 15 is a 6.1 g/m<sup>2</sup> (1.8 oz/yd<sup>2</sup>) SMS fabric laminate (C/P/C) bonded with an EHP bonding pattern. Sample 16 is a 57.65 g/m<sup>2</sup> (1.7 oz/yd<sup>2</sup>) SMS fabric laminate (C/P/C) bonded with a 714 bonding pattern.

35 The samples were all laundered in accordance with the requirements of the Recommended Practices of the Institute of Environmental Sciences October, 1987, IES-RP-CC-00387-T in a class 10 clean room (FED-STD-209D) so that particles on the samples left over from the manufacturing process would not skew the test results. The laundered samples were tested both using the Helmke Drum Test carried out in accordance with IES-RP-CC-00387-T and the Climet Lint Test carried out in accordance with INDA Std. Test 160.0-83. The results are tabulated in Table 5 below:

45

50

55

TABLE 5

		Sample 13 (Sam- ple 17 Table 6)	Sample 14 (Sam- ple 18 Table 6)	Sample 15 (Sam- ple 20 Table 6)	Sample 16 (Sam- ple 19 Table 6)
5	<b>Material</b>		P/P/P	P/P/P	C/P/C
10	<b>Basis Weight</b>		1.8	1.5	1.8
15	<b>Bond Pattern</b>		EHP	HP	EHP
20	<b>Helmke Particle Emission (Parti- cles/ft<sup>2</sup> of fabric lami- nate/ft<sup>3</sup>/minute)</b>				
25	>0.3 microns		247 ± 77	NT	5 ± 2
30	>0.5 microns		182 ± 62	98 ± 48	3 ± 2
35	<b>Climet Lint (Total Particles/ft<sup>2</sup>)</b>				
40	<b>Test Time (min):</b>	0.6	13	14	3
45		5.0	383	NT	58
50		8.0	966	NT	175
55		10.0	1700	NT	447

As can be seen from Table 5, it is clear that fabric laminates made using the propylene copolymer (3.2% ethylene) produced substantially less particle emissions than the conventional fabric laminates formed from isotactic polypropylene filaments and fibers.

It appears that the advantages of low particle emission can be achieved by using a copolymer for the external spun-bonded layers of an SMS fabric laminate which copolymer results from copolymerizing 0.5 to 5.0% by weight of ethylene randomly in the backbone of polypropylene. For low particle emission SMS fabric laminates a 3.2% ethylene copolymer is preferred. It has also been found that blends of olefins are useful for forming the external spun-bonded layers of a low particle emission SMS fabric laminate. Particularly, it has been found that a blend of polypropylene and polybutylene for forming the spun-bonded layers of an SMS fabric laminate can produce a low emission fabric laminate as compared to conventional polypropylene SMS fabric laminates. The blend of polypropylene and polybutylene can be in the range of from 5 to 20% by weight of polybutylene with 5% by weight of polybutylene preferred.

The adaptability of the inventive copolymer and polymer blends to SMS fabric laminates for clean room garments is further shown by the following example.

#### Example 5

In order to demonstrate the improved particle emissions characteristics of fabric laminates made in accordance with the present invention, seven SMS fabric laminate samples (Samples 17 through 23) were prepared and tested by means of the Helmke Drum Test. The characteristics of the samples and the results of the Helmke Drum Test are set forth in Table 6 below and illustrated in Fig. 5.

Two samples, Samples 17 and 18, are conventional SMS fabric laminates prepared from isotactic polypropylene. Sample 17 (which is in fact five separate samples) is an SMS fabric laminate sold by Kimberly-Clark and converted into garments under the trademark KleenGuard®. The SMS fabric laminate has a total basis weight of 6.1 g/m<sup>2</sup> (1.80 oz/yd<sup>2</sup>), with the internal melt-blown layer having a basis weight of 20,35 g/m<sup>2</sup> (0.60 oz/yd<sup>2</sup>). Sample 18 (which was in fact five separate samples) is an SMS fabric laminate sold by Kimberly-Clark under the trademark KleenGuard® and has a total basis weight of 50,86 g/m<sup>2</sup> (1.50 oz/yd<sup>2</sup>), with the internal melt-blown layer having a basis weight of 15,26 g/m<sup>2</sup> (0.45 oz/yd<sup>2</sup>).

Samples 19 through 22 were made in accordance with the present invention. Each of the Samples 19 through 22 is an SMS fabric laminate. The external layers of Samples 19 through 22 are spun-bonded and formed of a copolymer resulting from copolymerizing 3.2% by weight of ethylene randomly in the backbone of polypropylene. The internal melt-blown layer of each sample is formed of isotactic polypropylene. Sample 19 (in fact five samples) has a basis weight of 59,34 g/m<sup>2</sup> (1.75 oz/yd<sup>2</sup>), with the internal melt-blown layer having a basis weight of 14,24 g/m<sup>2</sup> (0.42 oz/yd<sup>2</sup>). Sample 20 (in fact five samples) has a total basis weight of 6.1 g/m<sup>2</sup> (1.80 oz/yd<sup>2</sup>), with the melt-blown internal layer having a

basis weight of 20.35 g/m<sup>2</sup> (0.60 oz/yd<sup>2</sup>). Sample 21 (in fact five samples) has a total basis weight of 59.34 g/m<sup>2</sup> (1.75 oz/yd<sup>2</sup>), with the melt-blown internal layer having a basis weight of 14.24 g/m<sup>2</sup> (0.42 oz/yd<sup>2</sup>). Sample 22 (in fact three samples) is the same as Sample 21 except that Sample 22 has been sterilized by subjecting the sample to gamma radiation in accordance with standard practices specified by the FDA. In order to make the SMS fabric laminate stable for sterilization, the spun-bonded layers are treated with a hindered amine. Particularly, Chimasorb 944 manufactured by Allied Chemical Corporation of Morristown, New Jersey, is added in the amount of 0.75% by weight of the spun-bonded layers during the forming of the spun-bonded layers.

Sample 23 is an SMS fabric laminate made in accordance with the present invention. The internal melt-blown layer of Sample 23 is formed of isotactic polypropylene and having a basis weight of 20.35 g/m<sup>2</sup> (0.60 oz/yd<sup>2</sup>). The external spun-bonded layers were formed from a blend of isotactic polypropylene and 5% by weight of polybutylene. Each spun-bonded layers has a basis weight of 20.35 g/m<sup>2</sup> (0.60 oz/yd<sup>2</sup>) for a total basis weight of 6.1 g/m<sup>2</sup> (1.8 oz/yd<sup>2</sup>).

A comparison of the particle emission for Samples 17 through 23 is set forth in Table 6 below.

TABLE 6

SAMPLES	17 Conventional (Sample 13 Table 5)	18 Conventional (Sample 14 Table 5)	19 Low Emission 3.2% PE (Sample 16 Table 5)	20 Low Emission 3.2% PE (Sample 15 Table 5)	21 Low Emission 3.2% PE	22 Low Emission 3.2% PE Sterile	23 Low Emission Blend
Material	P/P/P	P/P/P	C/P/C	C/P/C	C/P/C	C/P/C	C/P/C
Total Basis Weight (oz/yd <sup>2</sup> ) x 33.91 g/m <sup>2</sup>	1.80	1.50	1.75	1.80	1.75	1.75	1.80
Melt-blown (oz/yd <sup>2</sup> ) x 33.91 g/m <sup>2</sup>	0.60	0.45	0.42	0.60	0.42	0.42	0.60
Bond Pattern	EHP	HP	714	EHP	714	714	EHP
Area (ft <sup>2</sup> ) x 0.0929 m <sup>2</sup>	4.50	9.62	9.62	4.50	9.62	9.62	2.67
Particles >5.0 $\mu$	18.05		1.55	0.25			6.20
Particles >1.0 $\mu$	76.52		5.17	1.83			36.89
Particles >0.5 $\mu$	181.96	98.12	8.99	3.03	5.60	3.56	65.00
Particles >0.3 $\mu$	247.61		12.39	4.95			86.01

As can be seen from Table 6, the samples made in accordance with the present invention, Samples 19 through 22, produce far less particle emissions than the conventional SMS fabric laminates, Samples 17 and 18. The particle count for particles less than 0.5 microns was ten times less for Samples 19 through 22 than for the conventional polypropylene Samples 17 and 18. Even Sample 23, with its blend of polypropylene and 5% polybutylene used for making its spun-bonded layers, outperformed the conventional polypropylene Samples 17 and 18.

In order to further demonstrate the low emission characteristics of the SMS fabric laminate made from a low crystalline olefin copolymer, clean room garments were fabricated and used in the operation of a class 10 clean room laundry. A class 10 clean room laundry launders and packages clean room garments. The clean room garment embodying the present invention is shown in Fig. 7. The garment shown in Fig. 7 is in most respects the same as the protective garments sold by Kimberly-Clark under the trademark KleenGuard®. The garment shown in Fig. 7 is different in several ways. The garment is made from the SMS fabric laminate of the present invention. In addition the test garments were fabricated with monofilament nylon thread and the fabric was double rolled around the elastic at the cuffs of the arms and legs to minimize particulate emission from the elastic.

The particular clean room laundry used to test the garments made in accordance with the present invention was in the business of laundering and packaging conventional woven polyester garments and conventional garments made of Tyvek®. Tyvek® is a registered trademark of Dupont of Wilmington, Delaware. For the purpose of the test, a Climet CI-8060 particle counter was set up inside the clean room laundry, and samples were taken at various locations. The workers, 3 - 4 per shift, were monitored for particulate emissions while wearing the following garments:

Garment 1. Woven polyester, manufactured by Mars White Knight or HiTech;  
 Garment 2. 59,34 g/m<sup>2</sup> (1.75 oz/yd<sup>2</sup>) SMS fabric laminate (C/P/C; 3.2% ethylene) unsterile; and  
 Garment 3. 59,34 g/m<sup>2</sup> (1.75 oz/yd<sup>2</sup>) SMS fabric laminate (C/P/C; 3.2% ethylene) sterile (gamma).

Garment 1 of woven polyester is a conventional clean room garment. Garments 2 and 3 are garments fabricated in accordance with the present invention from an SMS fabric laminate having the external spun-bonded layers formed from a low crystalline propylene copolymer of 3.2% ethylene and the internal melt-blown layer formed from isotactic polypropylene. Sterilization was done by gamma rays in conventional fashion. All workers wore woven polyester hoods (Mars White Knight or HiTech), woven polyester boots (HiTech), and vinyl gloves at all times.

It should be noted that the work conducted inside the clean room laundry, laundering, fluffing, folding, and packaging, can cause considerable amount of variability in the amount of generated particulate. Because of this, the matrix for conducting the test included testing with respect to each of the jobs performed in the clean room laundry and during the laundering of the different conventional garments, Tyvek® and woven polyester garments. The matrix of garments worn and garments laundered is set forth in Table 7, below:

TABLE 7

GARMENTS LAUN- DERED	GARMENTS WORN		
	Garment 1 Woven Poly- ester	Garment 2 SMS (3.2% E) Unsterile	Garment 3 SMS(3.2% E) Sterile
Woven Polyester	1/1		3/1
Tyvek Coveralls	1/2	2/2	3/2
Tyvek Hood/Boots	1/3		3/3

The blanks in Table 7 resulted from the inability to complete all segments of the matrix because of the commercial laundry's production schedule.

In taking the particle emission data, sampling was done at the various locations about the clean room. It was determined that the area of greatest particle emissions was under the feet of the worker whose job was fluffing and folding the laundered garments. This particular job was continuously performed whereas other jobs in other areas were only performed sporadically and on a limited basis. Therefore, all of the measurements were made at the location where the fluffing and folding was performed. Moreover, the worker at the location of the fluffing and folding during the 2 1/2 days of testing was the same person, thereby eliminating variation resulting from different individuals.

Data was taken and statistically analyzed according to Federal Standard 209D. It should be noted that this standard requires the use of a number of locations to determine the classification of a clean room. For the purpose of this study, analysis of the garments worn only in the one location (fluffing and folding) was used in order to assure worst case performance. It was believed that the other locations, because of the limited use, would give misleadingly positive results as to the performance of all of the garments.

In order to comply with Federal Standard 209D particulate levels were measured at one particle size (usually 0.5 microns) and statistically analyzed. The upper confidence limit at 95% was then compared to the classifications for the clean room set forth in Table 4, above. The results of the testing is shown in Figure 6. The matrix entries 1/2, 1/3, and 1/1 represent data taken while the conventional woven polyester garment was being worn and therefore those entries and the corresponding data are the control entries. When the two inventive garments, garments 2 and 3, were substituted for the conventional woven polyester garment, the particulate count decreased in all cases where the materials of the garments being laundered remained the same. Consequently, one can conclude that the garments made in accordance with the present invention themselves produced less particulate emission than conventional woven polyester clean room garments.

## Claims

1. A nonwoven fabric laminate comprising a first layer of thermoplastic filaments formed from a first thermoplastic polymer and a second layer of discrete thermoplastic fibres formed from a second thermoplastic polymer, wherein the layers are positioned in laminar surface-to-surface relationship, wherein the layers are heat bonded in discrete areas, and wherein the thermoplastic polymer in at least said first layer is an olefin copolymer having a crystallinity of less than 45%.
2. The nonwoven fabric laminate of claim 1, wherein the olefin copolymer has a crystallinity between 31-35%.
3. The nonwoven fabric laminate of claim 1, wherein the olefin copolymer has a crystallinity of about 32%.
4. The nonwoven fabric laminate of any one of claims 1 to 3, wherein the olefin copolymer is polypropylene modified by copolymerizing 0.5-5.0% ethylene randomly in the backbone.
5. A nonwoven fabric laminate comprising a first layer of thermoplastic filaments formed from a first thermoplastic polymer and a second layer of discrete thermoplastic fibres formed from a second thermoplastic polymer, wherein the layers are positioned in laminar surface-to-surface relationship, wherein the layers are heat bonded in discrete areas, and wherein the thermoplastic polymer in at least said first layers is an olefin terpolymer having a crystallinity of less than 45%.
6. The nonwoven fabric laminate of claim 5, wherein the olefin terpolymer has a crystallinity between 31-35%.
7. The nonwoven fabric laminate of claim 5, wherein the olefin terpolymer has a crystallinity of about 32%.
8. A nonwoven fabric laminate according to any one of claims 1 to 4 comprising in sequence the first layer, the second layer and a third layer of thermoplastic filaments formed from a third thermoplastic polymer, wherein the layers are heat bonded in discrete areas and wherein each of the first and third thermoplastic polymers is an olefin copolymer having a crystallinity of less than 45%.
9. The nonwoven fabric laminate of claim 8, wherein the olefin copolymer has a crystallinity between 31-35%.
10. The nonwoven fabric laminate of claim 8, wherein the olefin copolymer has a crystallinity of about 32%.
11. The nonwoven fabric laminate of any one of claims 8 to 10, wherein the olefin copolymer is polypropylene modified by copolymerizing 0.5-5.0% ethylene randomly in the backbone.
12. A nonwoven fabric laminate according to any one of claims 5 to 7 comprising in sequence the first layer, the second layer, and a third layer of thermoplastic filaments formed from a third thermoplastic polymer, wherein the layers are heat bonded in discrete areas and wherein each of the first and third thermoplastic polymers is an olefin terpolymer having a crystallinity of less than 45%.
13. The non-woven fabric laminate of claim 12 wherein the olefin terpolymer has a crystallinity between 31-35%.
14. The non-woven fabric laminate of claim 12, wherein the olefin terpolymer has a crystallinity of about 32%.
15. The non-woven fabric laminate of any one of claims 1 to 14 wherein the layer of thermoplastic filaments comprises continuous spunbonded filaments, and the layer of discrete thermoplastic fibres comprises meltblown fibres.
16. A low particle emitting garment comprising a non-woven fabric laminate in accordance with any one of the preceding claims.
17. A medical sterile wrap comprising a non-woven fabric laminate in accordance with any one of claims 1 through 15.
18. A surgical gown comprising a non-woven fabric laminate in accordance with any one of claims 1 through 15.
19. A sterilisable clean room garment comprising a non-woven fabric laminate in accordance with any one of claims 1 through 15.

## Patentansprüche

1. Nicht-gewebtes Textil-Laminat mit einer ersten Schicht aus thermoplastischen Filamenten, die aus einem ersten thermoplastischen Polymer hergestellt sind, und einer zweiten Schicht aus einzelnen thermoplastischen Fasern, die aus einem zweiten thermoplastischen Polymer hergestellt sind, wobei die Schichten in einer laminaren Anordnung, Oberfläche an Oberfläche, angeordnet sind, wobei die Schichten in einzelnen Bereichen thermisch gebunden sind, und wobei das thermoplastische Polymer in mindestens der ersten Schicht ein Olefin-Copolymer mit einer Kristallinität von weniger als 45% ist.
2. Nicht-gewebtes Textil-Laminat nach Anspruch 1, wobei das Olefin-Copolymer eine Kristallinität zwischen 31 bis 35 % aufweist.
3. Nicht-gewebtes Textil-Laminat nach Anspruch 1, wobei das Olefin-Copolymer eine Kristallinität von etwa 32 % aufweist.
4. Nicht-gewebtes Textil-Laminat nach einem der Ansprüche 1 bis 3, wobei das Olefin-Copolymer ein Polypropylen ist, modifiziert durch Copolymerisation von 0,5 bis 5,0 % Äthylen statistisch in der Hauptkette.
5. Nicht-gewebtes Textil-Laminat mit einer ersten Schicht aus thermoplastischen Filamenten, hergestellt aus einem ersten thermoplastischen Polymer, und einer zweiten Schicht aus einzelnen thermoplastischen Fasern, hergestellt aus einem zweiten thermoplastischen Polymer, wobei die Schichten in einer laminaren Anordnung, Oberfläche an Oberfläche, angeordnet sind, wobei die Schichten in einzelnen Bereichen thermisch gebunden sind, und wobei das thermoplastische Polymer in mindestens den ersten Schichten ein Olefin-Terpolymer mit einer Kristallinität von weniger als 45 % ist.
6. Nicht-gewebtes Textil-Laminat nach Anspruch 5, wobei das Olefin-Terpolymer eine Kristallinität zwischen 31 bis 35 % aufweist.
7. Nicht-gewebtes Textil-Laminat nach Anspruch 5, wobei das Olefin-Terpolymer eine Kristallinität von etwa 32 % aufweist.
8. Nicht-gewebtes Textil-Laminat nach einem der Ansprüche 1 bis 4, umfassend nacheinander die erste Schicht, die zweite Schicht und eine dritte Schicht aus thermoplastischen Filamenten, hergestellt aus einem dritten thermoplastischen Polymer, wobei die Schichten in einzelnen Bereichen thermisch gebunden sind, und wobei jede der ersten und dritten thermoplastischen Polymere ein Olefin-Copolymer mit einer Kristallinität von weniger als 45 % ist.
9. Nicht-gewebtes Textil-Laminat nach Anspruch 8, wobei das Olefin-Copolymer eine Kristallinität zwischen 31 bis 35 % aufweist.
10. Nicht-gewebtes Textil-Laminat nach Anspruch 8, wobei das Olefin-Copolymer eine Kristallinität von etwa 32 % aufweist.
11. Nicht-gewebtes Textil-Laminat nach einem der Ansprüche 8 bis 10, wobei das Olefin-Copolymer ein durch Copolymerisation mit 0,5 bis 5 % Äthylen statistisch in der Hauptkette modifiziertes Polypropylen ist.
12. Nicht-gewebtes Textil-Laminat nach einem der Ansprüche 5 bis 7, umfassend nacheinander die erste Schicht, die zweite Schicht und eine dritte Schicht aus thermoplastischen Filamenten, die aus einem dritten thermoplastischen Polymer hergestellt sind, wobei die Schichten in einzelnen Bereichen thermisch gebunden sind, und wobei jeder der ersten und dritten thermoplastischen Polymere ein Olefin-Terpolymer mit einer Kristallinität von weniger als 45% ist.
13. Nicht-gewebtes Textil-Laminat nach Anspruch 12, wobei das Olefin-Terpolymer eine Kristallinität zwischen 31 bis 35 % aufweist.
14. Nicht-gewebtes Textil-Laminat nach Anspruch 12, wobei das Olefin-Terpolymer eine Kristallinität von etwa 32 % aufweist.
15. Nicht-gewebtes Textil-Laminat nach einem der Ansprüche 1 bis 14, wobei die Schicht aus thermoplastischen Filamenten kontinuierlich spin gebundene Filamente umfaßt, und die Schicht aus einzelnen thermoplastischen

Fasern schmelzgeblasene Fasern umfaßt.

16. Kleidungsstück mit niedriger Partikelemission umfassend ein nicht-gewebtes Textil-Laminat nach einem der vor-  
angegangenen Ansprüche.

5 17. Medizinische, sterile Umhüllung umfassend ein nichtgewebtes Textil-Laminat nach einem der Ansprüche 1 bis 15.

18. Medizinische Kleidung umfassend ein nicht-gewebtes Textillaminat nach einem der Ansprüche 1 bis 15.

10 19. Sterilisierbares Reinraumkleidungsstück umfassend ein nicht-gewebtes Textil-Laminat nach einem der Ansprüche 1 bis 15.

#### Revendications

15 1. Stratifié textile en non-tissé comprenant une première couche de filaments thermoplastiques formés à partir d'un premier polymère thermoplastique et une deuxième couche de fibres thermoplastiques discrètes formées à partir d'un deuxième polymère thermoplastique, dans lequel les couches sont positionnées dans une relation de stratifié de surface à surface, dans lequel les couches étant thermoliées dans des zones discrètes, et dans lequel le polymère thermoplastique dans au moins ladite première couche est un copolymère d'oléfine ayant une cristallinité, inférieure à 45%.

20 2. Stratifié textile en non-tissé selon la revendication 1, dans lequel le copolymère d'oléfine a une cristallinité comprise entre 31 et 35%.

25 3. Stratifié textile en non-tissé selon la revendication 1, dans lequel le copolymère d'oléfine a une cristallinité d'environ 32%.

30 4. Stratifié textile en non-tissé selon l'une quelconque des revendications 1 à 3, dans lequel le copolymère d'oléfine est un polypropylène modifié en copolymérisant statistiquement de 0,5 à 5,0% d'éthylène dans la chaîne principale linéaire.

35 5. Stratifié textile en non-tissé comprenant une première couche de filaments thermoplastiques formés à partir d'un premier polymère thermoplastique et une deuxième couche de fibres thermoplastiques discrètes formées à partir d'un deuxième polymère thermoplastique, dans lequel les couches sont positionnées dans une relation de stratifié de surface à surface, dans lequel les couches sont thermoliées dans des zones discrètes, et dans lequel le polymère thermoplastique dans au moins lesdites premières couches est un terpolymère d'oléfine ayant une cristallinité inférieure à 45%.

40 6. Stratifié textile en non-tissé selon la revendication 5, dans lequel le terpolymère d'oléfine a une cristallinité comprise entre 31 et 35%.

7. Stratifié textile en non-tissé selon la revendication 5, dans lequel le terpolymère d'oléfine a une cristallinité d'environ 32%.

45 8. Stratifié textile en non-tissé selon l'une quelconque des revendications 1 à 4 comprenant en séquence la première couche, la deuxième couche et une troisième couche de filaments thermoplastiques formés à partir d'un troisième polymère thermoplastique, dans lequel les couches sont thermoliées dans des zones discrètes, et dans lequel les premier et troisième polymères thermoplastiques sont, chacun, un copolymère d'oléfine ayant une cristallinité inférieure à 45%.

50 9. Stratifié textile en non-tissé selon la revendication 8, dans lequel le copolymère d'oléfine a une cristallinité comprise entre 31 et 35%.

10. Stratifié textile en non-tissé selon la revendication 8, dans lequel le copolymère d'oléfine a une cristallinité d'environ 32%.

55 11. Stratifié textile en non-tissé selon l'une quelconque des revendications 8 à 10, dans lequel le copolymère d'oléfine est un polypropylène modifié en copolymérisant statistiquement de 0,5 à 5,0% d'éthylène dans la chaîne principale linéaire.

12. Stratifié textile en non-tissé selon l'une quelconque des revendications 5 à 7 comprenant en séquence la première couche, la deuxième couche et une troisième couche de filaments thermoplastiques formés à partir d'un troisième polymère thermoplastique, dans lequel les couches sont thermoliées dans des zones discrètes, et dans lequel les premier et troisième polymères thermoplastiques sont, chacun, un terpolymère d'oléfine ayant une cristallinité inférieure à 45%.

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13. Stratifié textile en non-tissé selon la revendication 12, dans lequel le terpolymère d'oléfine a une cristallinité comprise entre 31 et 35%.

10 14. Stratifié textile en non-tissé selon la revendication 12, dans lequel le terpolymère d'oléfine a une cristallinité d'environ 32%.

15 15. Stratifié textile en non-tissé selon l'une quelconque des revendications 1 à 14, dans lequel la couche de filaments thermoplastiques comprend des filaments filés en nappes continus, et la couche de fibres thermoplastiques discrètes comprend des fibres soufflées au fondu.

16. Vêtement à faible émission de particules comprenant un stratifié textile en non-tissé selon l'une quelconque des revendications précédentes.

20 17. Emballage stérile à usage médical comprenant un stratifié textile en non-tissé selon l'une quelconque des revendications 1 à 15.

18. Blouse chirurgicale comprenant un stratifié textile en non-tissé selon l'une quelconque des revendications 1 à 15.

25 19. Vêtement pour salle blanche stérilisable comprenant un stratifié textile en non-tissé selon l'une quelconque des revendications 1 à 15.

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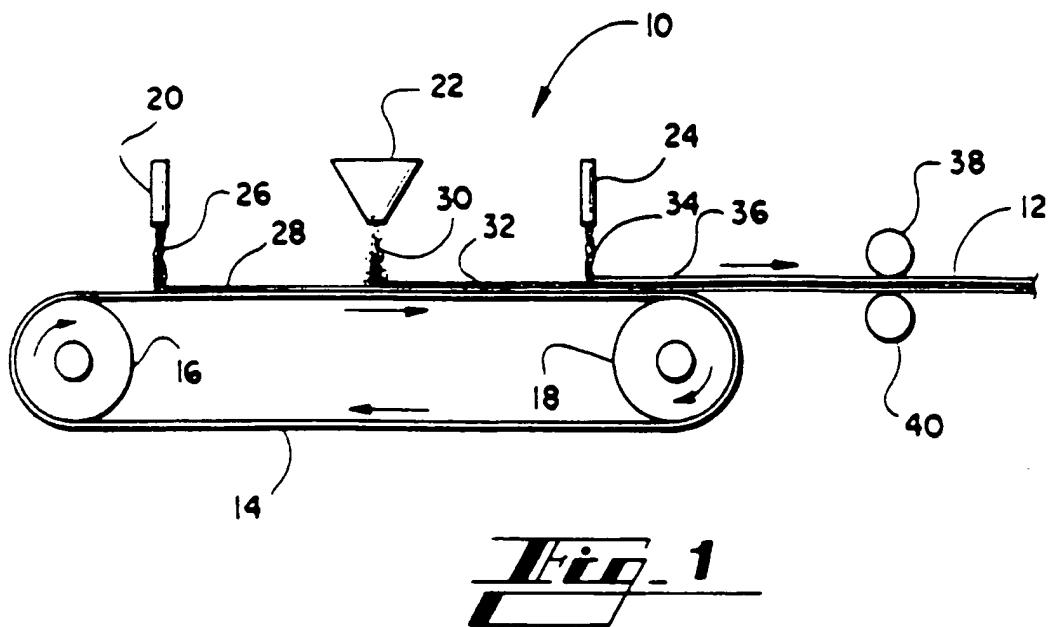


Fig. 1

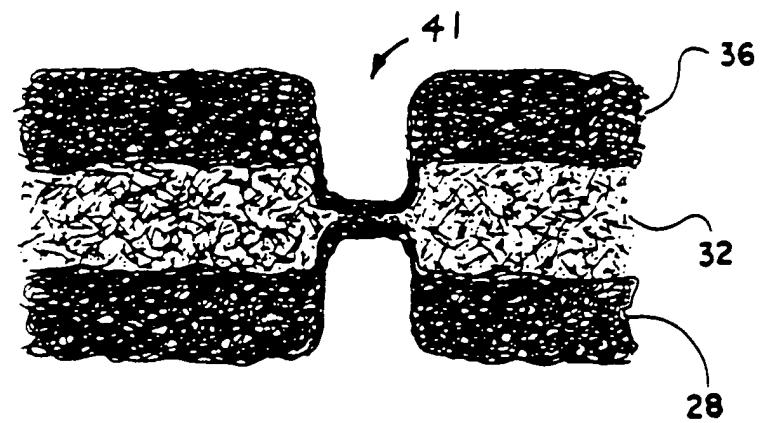
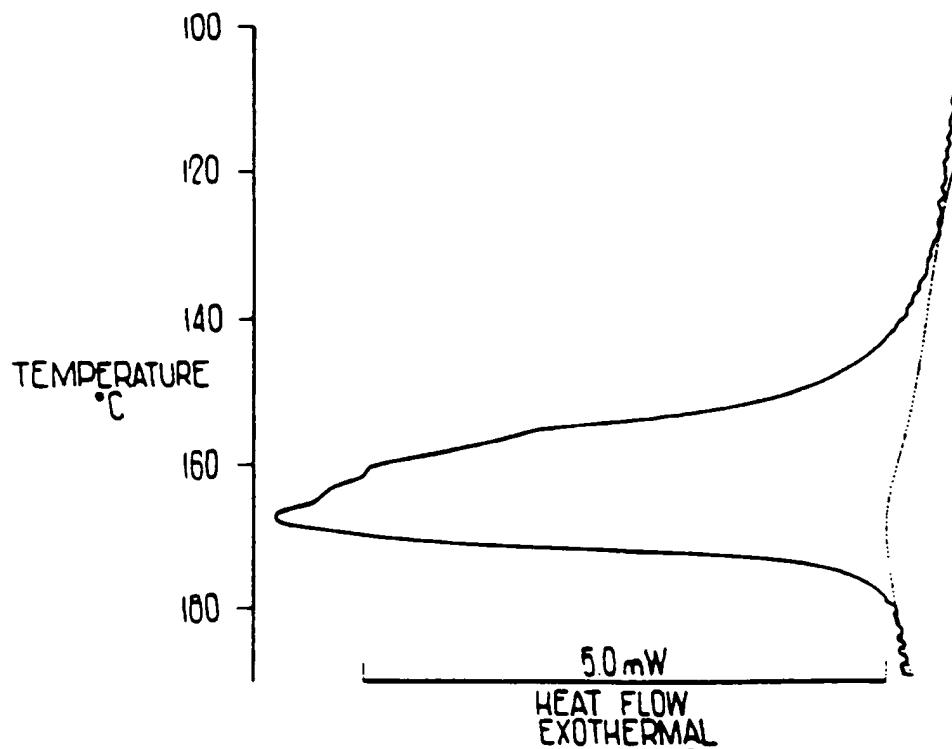
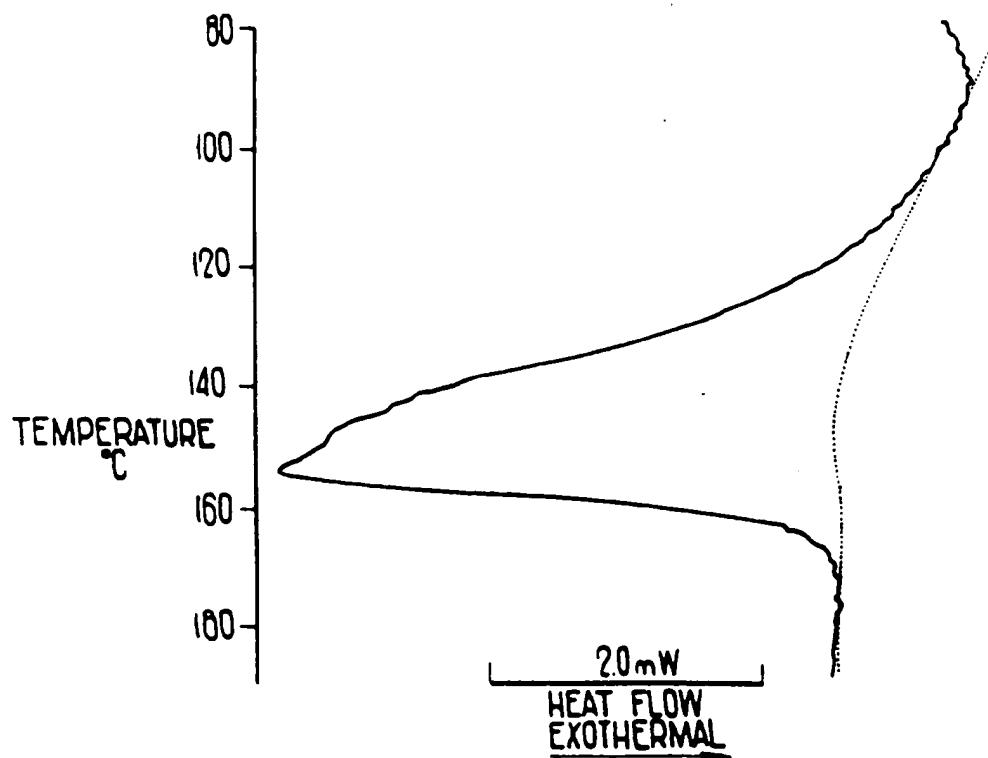


Fig. 2

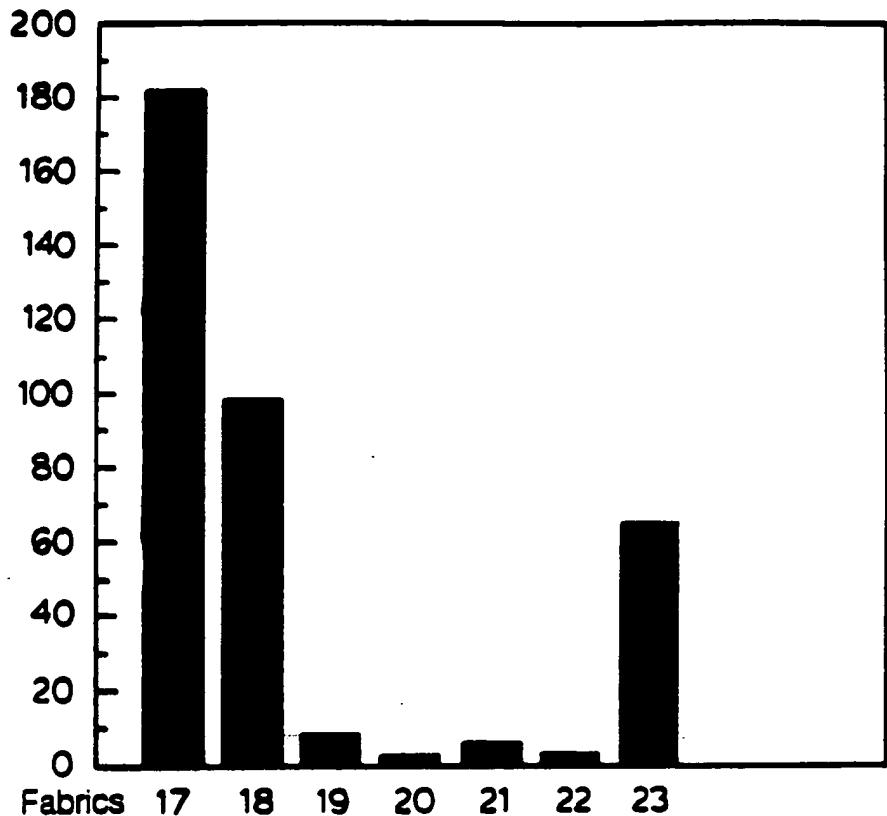


**FIG 3**  
PRIOR ART



**FIG 4**

**HELMKE DRUM TEST**  
**Average Particle Count  $> 0.5\mu$**   
**PER  $0.093 \text{ m}^2 (\text{FT}^2)$  OF FABRIC**  
**PER  $0.028 \text{ m}^3 (\text{FT}^3)$  PER MINUTE**



**SAMPLE 13/17 - CONVENTIONAL SMS**  
**SAMPLE 14/18 - CONVENTIONAL SMS**  
**SAMPLE 16/19 - LOW EMISSION SMS**  
**SAMPLE 15/20 - LOW EMISSION SMS**  
**SAMPLE 21 - LOW EMISSION SMS**  
**SAMPLE 22 - STERILE LOW EMISSION SMS**  
**SAMPLE 23 - LOW EMISSION SMS (BLEND)**

**FIG. 5**

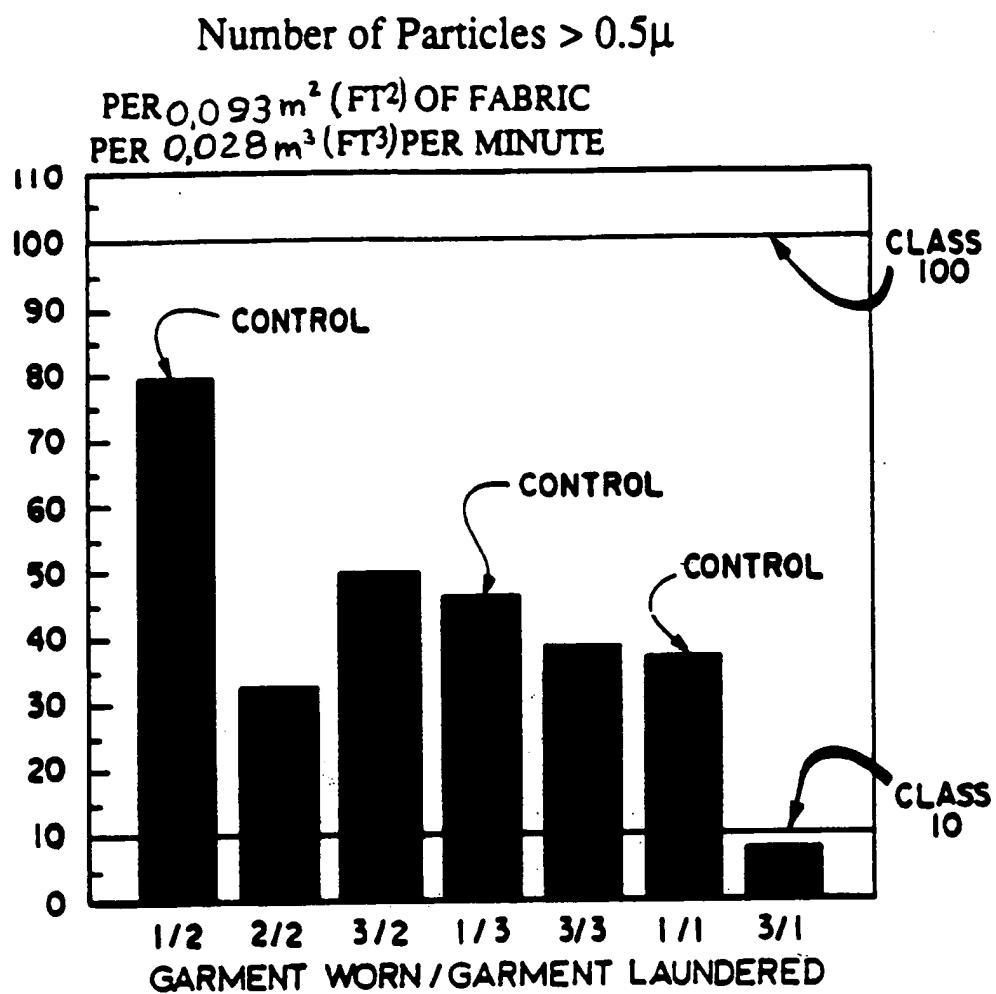


FIG. 6

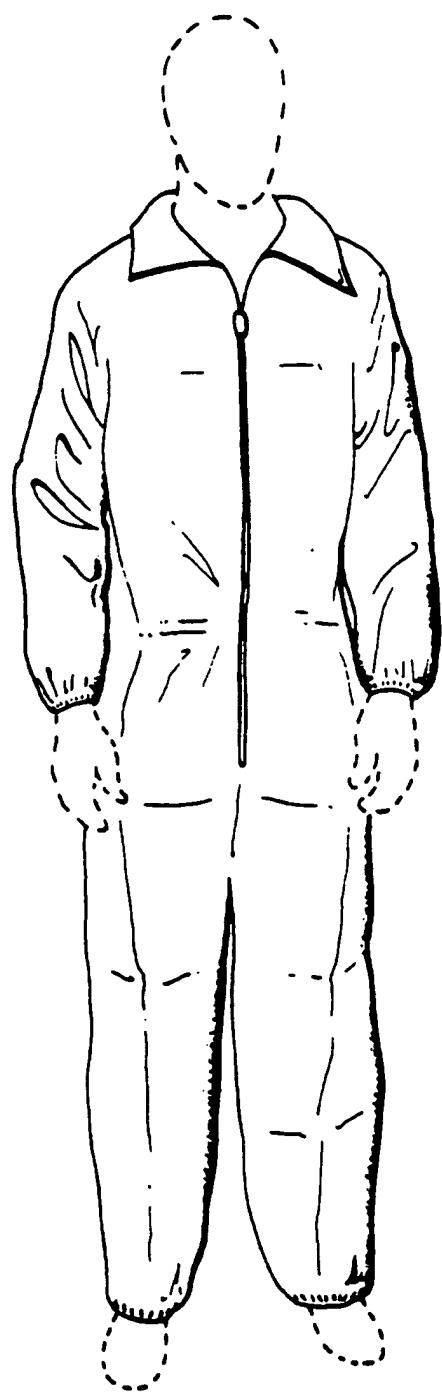


Fig. - 7